ORD's water research program furnishes the tools used by EPA's Office of Water to protect the Nation's freshwater and coastal resources. ORD also develops tools and techniques to assess damage to aquatic systems; identify the sources of the damage; and forecast the ecological, human health, and economic outcomes of alternative solutions to water quality problems. ORD also investigates methods to clean up contaminated sites, including those with contaminated groundwater and contaminated sediments.

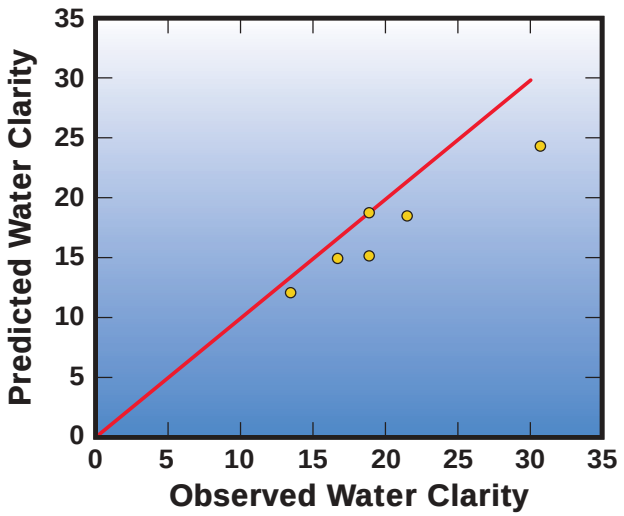
Water Quality

This chapter presents a diverse sampling of recent accomplishments by ORD scientists who are studying ways to preserve and restore the quality of the Nation's water resources.

MODELING WATER QUALITY

Water quality in Lake Tahoe in California, including the lake's remarkable water clarity, has been deteriorating since the 1960s. ORD awarded scientists at the University of California-Davis a grant to study how soil erosion and pollutant transport from the surrounding land area affect the lake. The researchers developed a series of integrated computer models to simulate sediment and nutrient transport and other factors affecting water clarity. Equipped with this computer modeling system, scientists and water resource managers will be able to identify the sources and relative contributions of sediments and nutrients to Lake Tahoe. In addition, resource managers will be able to determine how much these inputs to the lake must be reduced to attain the desired water clarity.

The sediment transport model, which is one component of the complete system, simulates soil erosion and the movement of sediment and nutrients from surrounding watersheds into Lake Tahoe. This model predicts how changes in land surface/vegetation cover (e.g., roads, urbanization, and forest practices) may affect the water, sediment, and nutrient balances in Lake Tahoe watersheds. The model can also forecast the effects of flooding and estimate how changing climatic conditions may impact the area's long-term water balance.



The water clarity model showed good agreement between water clarity predicted by the model (—) and water clarity observed in Lake Tahoe (●).

The water clarity model provides critical information for long-term water resource planning at Lake Tahoe. The model allows scientists to predict changes in water clarity based on the lake's capacity to receive and process sediments and nutrients. Because of specific design features, this model should be applicable to other watersheds without extensive adjustments to accommodate local conditions.

IDENTIFYING STRESSES TO ECOSYSTEMS

Identifying the factors causing biological impairment in aquatic ecosystems, and defending the actions taken based on the supporting evidence, is an important part of EPA's decision-making process. ORD, EPA's Office of Water, Colorado State University, and several state environmental agencies worked cooperatively to develop and test an approach that will meet the needs of water resource managers at all levels of government.

Completed in December 2000, the *Stressor Identification Guidance Document* provides a method for identifying the factors that cause damage to an aquatic community. The document describes a systematic procedure that water resource managers can follow to identify manmade or natural causes of an impairment. In addition to a detailed description of this procedure, the guidance document also includes case studies that demonstrate how to apply this approach.

Sampling waste effluent from a solids separator at a concentrated animal feeding operation.

Sampling a creek upstream from the operation.

REMEDIATING PCB-CONTAMINATED SEDIMENTS

Polychlorinated biphenyls (PCBs) are toxic chemicals that persist in the environment for years and accumulate in human body tissues and in wildlife through food webs. In the United States, sediments contaminated with PCBs are a widespread problem. Subsistance fishermen and top wildlife predators are often at the greatest risk of exposure to PCBs due to bioaccumulation through the food web.

In nature, top predators have more PCBs per unit of body weight than the animals and plants they eat.

Dredging has been used as one of several methods to remediate PCB-contaminated sediments. In response to concerns that dredging PCB-contaminated sediments might have adverse environmental and public health consequences, Congress directed the EPA to evaluate the availability, effectiveness, and costs of various technologies for cleaning up these sediments. EPA contracted the National Academy of Sciences to conduct the study, the results of which were released in March, 2001 in the report *A Risk Management Strategy for PCB-Contaminated Sediments*. The report concluded that PCBs pose health and ecological threats and that exposure to these persistent chemicals may cause chronic illnesses such as cancer and immunological, developmental, reproductive, and neurological problems in humans and wildlife. The report also concluded that there is no single cleanup technology suitable for all PCB-contaminated sites, supporting EPA's site-specific approach toward remediation. This report supports ongoing ORD

research on persistent, bioaccumulative and toxic chemicals as well as contaminated sediment projects conducted by both EPA's Office of Solid Waste and Emergency Response and Office of Water. Many of the research needs listed in the report are being addressed by ORD in collaboration with the Office of Water and the Office of Solid Waste and Emergency Response. This partnership recently led to the development of a methods compendium for identifying toxic chemicals at contaminated sites.

EVALUATING SEDIMENT TOXICITY

Contaminated sediments from a number of freshwater and marine sites have caused declines in wildlife populations and changes in ecological community structure. However, simply knowing that a sediment is toxic is of limited value. The specific chemicals causing toxic effects must be identified before appropriate action can be taken. The ability to identify the specific pollutants responsible for the toxicity of contaminated sediments is important to the development of water quality criteria and sediment quality guidelines and to EPA regulatory programs that deal with dredged material disposal.

ORD recently completed a manual addressing this issue, the *Sediment Toxicity Identification and Evaluation Guidance Document*. Using the methods described in this document, scientists and resource managers can identify chemicals (or chemical classes) in sediment or in the water column responsible for an observed toxicity.

The toxicity identification and evaluation process is divided into three phases: characterization, identification, and confirmation. During characterization, the general category or type of toxic material involved (e.g., metals, volatiles, oxidants) is determined. In the identification phase, the causative toxic material is isolated from other chemicals in the sample. During confirmation, additional data are collected until enough evidence is accumulated to confirm beyond reasonable doubt that the suspect toxic material is in fact causing the toxicity.

LOOKING TO THE FUTURE

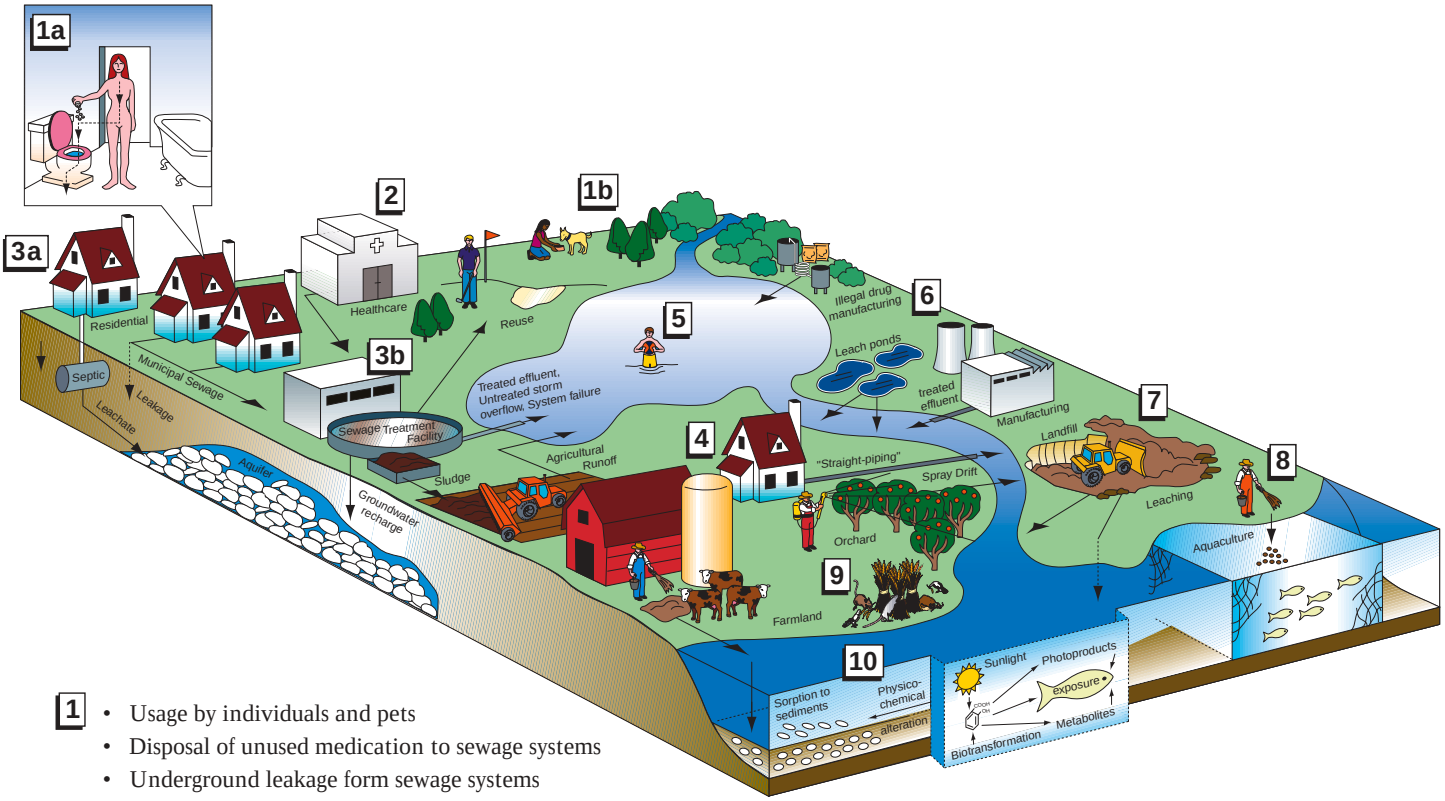
Research milestones anticipated in the near future include

- *an evaluation of watershed classification schemes used to study the response of aquatic ecosystems to excessive nutrients;*
- *a report on performance and cost data for controlling nutrients, sediments, pathogens, toxic chemicals, and water flow variations in watersheds with a variety of land uses;*
- *molecular diagnostic techniques to identify toxic organisms (e.g.,* pfiesteria*) and determine their distribution;*
- *a report comparing dredging, capping, and monitored natural attenuation as three alternative waste management solutions for contaminated sediments; and*
- *an evaluation of methods to assess the ecological effects of bioaccumulative organic chemicals in sediments.*

Pharmaceuticals and Personal Care Products

Pharmaceuticals and personal care products (PPCPs) include prescription drugs, nutritional supplements, fragrances, medical diagnostic agents, sunscreen agents, and other related products for both human and veterinary use. Although their concentrations may be extremely low, these substances are continually introduced to water environments through their use and disposal. The risks to aquatic organisms, from continual life-long exposure, and to humans, from long-term consumption of minute quantities in drinking water, are essentially unknown. ORD scientists are raising awareness about this emerging environmental issue and researching the numerous questions that remain to be answered. In 2001, ORD awarded six grants to academic researchers who will address some of the most important questions about pharmaceuticals and personal care products in the environment.

Origins and Fate of PPCPs in the Environment



1
- Usage by individuals and pets
- Disposal of unused medication to sewage systems
- Underground leakage form sewage systems

2
- Release of treated/untreated hospital wastes to sewage system

3
- Release to private septic systems
- Discharge of treated effluent from sewage treatment plants
- Overflow of untreated sewage due to storms and system failures

4
- Use of sewage solids as fertilizer and soil amendment
- Discharge of untreated sewage from homes to surface waters ("straight-piping")
- Release from domestic animals consuming medicated feed

5
- Release to open waters via washing/bathing/swimming

6
- Discharge of regulated/controlled industrial manufacturing waste
- Disposal/release from illegal drug labs

7
- Disposal of domestic refuse and medical wastes to landfills
- Leaching from defective landfills

8
- Release from fish farming operations using medicated feed

9
- Release of drugs that also serve as pest-control agents

10
- Most PPCPs are eventually transported from land to water, where they are transformed, degraded, or taken up by living organisms.